National Weather Service
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Hydrology Research to Operations Meeting

Abstracts

Title: “Development of a Teleconnections-based System for longer-lead Snowmelt Forecasting in Western U.S. Regions”

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An experimental system featuring teleconnections-based forecasting technology has been developed and deployed to several centers that produce snowmelt volume forecasts for Western U.S. basins (CNRFC, CA Department of Water Resources, NRCS, and Reclamation’s PN Regional Office). The system features longer-lead forecast models that enable issuing April-July volumetric runoff forecasts (i.e. snowmelt volume forecasts) in early October, November, and December. These centers currently offer snowmelt volume forecasts beginning in January. The system has several features, including: signal data import and management, signal data export to information systems at the forecast centers, longer-lead forecast reporting, and metadata on the signals.

The longer-lead forecast models use predictors based on seasonal geopotential height conditions over the North Pacific (i.e. 700mb heights, or height difference between the 500mb and 700mb levels, estimated by NCEP/NCAR Reanalysis). These height “signals” were selected for their historical relation to April-July natural runoff volumes for Western U.S. Basins (CA, NV, OR, WAS, ID, and MT). Signal selections are spatially focused within 5 degrees latitude by 10 degrees longitude regions. They occur during signal-seasons antecedent to the April-July runoff-season at various lead-times. Signal locations vary from Northeast Pacific at shorter-leads to Subtropical and Northwest Pacific at longer-leads. Signal correlation with snowmelt volume is generally 0.5 to 0.8 at shorter- and 0.4 to 0.6 at longer-leads. Signal selection was constrained by tests of correlation significance and physical plausibility. Signal selections were further screened for forecasting potential. Retained signals and associated forecast models were integrated into the model-data system.

Presentation will focus on a small set of basins, highlighting methods of signal identification, evaluation of signals’ for forecasting potential, development of forecast models, and deployment of the model/data system.

A multi-model hydrologic ensemble for seasonal streamflow forecasting in the western U.S.

Theodore Bohn, Andrew Wood, Ali Akanda, and Dennis Lettenmaier

Since 2003, the Variable Infiltration Capacity (VIC) macroscale hydrology model has been applied in real time over the western U.S. for experimental ensemble hydrologic prediction at lead times of six months to a year. VIC hydrologic initial conditions are produced from gridded station observations during a two-year runup period prior to the forecast date; and hydrologic forecast ensembles are driven by climate forecasts from several sources, including NCEP and NASA climate model outputs, CPC official seasonal outlooks and, as a baseline forecast, Extended Streamflow Prediction (ESP). We are now in the process of expanding this approach to include forecasts made from a Bayesian combination of the results from a suite of land surface models. The use of multiple models is facilitated by the Standard Interface MultiModel Array (SIMMA), a framework that automates model execution, model-specific data processing and the translation of model inputs and outputs to a common format. SIMMA's input/output data, stored in NetCDF format, conform to the Assistance for Land Model Activities (ALMA) convention, developed by the GEWEX Global Land Atmosphere System Study (GLASS). This common format facilitates the comparison and combination of model results. Initially, the LSMs included are VIC, the NWS grid-based Sacramento model (HL-RMS) and the NCEP NOAH model. All LSMs are implemented on an identical 1/8 degree grid. This presentation reports on preliminary results from a pilot application in the Salmon River basin, ID, focusing on retrospective simulations and ESP-based forecasts, and compares linear regression and Bayesian methods of combining model results.

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Reservoir Release Forecast Model for Flood Operation of the Folsom Project including Forecast-based Operations

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In addition to its hydropower, water supply and recreation purposes, the Folsom project plays an important role in protecting Sacramento from flooding. Combined with a levee system, it is estimated that the project will provide about a 1 in 100 AEP level of protection after levee strengthening is completed. Increased outlet capacity is being added to the Folsom Dam, thus expanding the potential for forecast-based pre-releases to increase flood control space immediately before floods and raising the protection level to about a 1 in 175 AEP.

Since 1996, a multi-agency steering group has worked with a Utah State University (USU) team to develop, test and implement the Reservoir Release Forecast Model (RRFM) for real time operation of the Folsom Reservoir. The steering group includes the U.S. Bureau of Reclamation (Reclamation), the U.S. Army Corps of Engineers (USACE), the Sacramento Area Flood Control Agency (SAFCA), the National Weather Service (NWS) California-Nevada River Forecast Center (CNRFC), the California Division of Water Resources (DWR), and the American River Flood Control District.

Reclamation operators are periodically trained in the use of RRFM, although it is only expected to be used in the case of extreme floods. The model captures various input variables, including inflow forecasts from a state-space version of the NWS Sacramento hydrology model (SS-SAC), and applies the flood control and emergency spillway release rules. It provides forecasts of release rates and timing, downstream river stages and reservoir refill. It can also provide probabilistic estimates for exceeding downstream channel capacities at various lead times to downstream emergency managers. It can be used to explore alternatives operating strategies and to produce release orders in real time.

In addition to the operational or real time mode, RRFM has a simulation-planning mode. This mode works "off line" using either batch or interactive (or pseudo real time) processing. It generates an ensemble of inflow forecasts with forecast error structure that statistically resembles that of historic floods. All output variables are presented in a probabilistic form. This mode can be used to run an historical event, design flood, or hypothetical inflow hydrographs for operator training, for assisting downstream emergency managers in developing protocols for using RRFM release forecasts to improve emergency planning and management, and for developing and testing operating rule changes, including possible forecast-based operating rules.

Our paper will describe the operational and simulation-planning modes and illustrate their application. Maintenance and training requirements to keep operating personnel proficient in its use will be addressed. On-going efforts to improve the representation of inflow forecast errors in the simulation-planning mode and the use of NWS ensemble forecasts in the Operational Mode will be discussed.

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Post-Wildfire Debris Flows from a Geologic Perspective and Rainfall Intensity-Duration Thresholds as the Basis for Post-Wildfire Flash Flood and Debris Flow Warnings

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Wildland fire can have profound effects on the hydrologic response of a watershed. Consumption of the rainfall-intercepting canopy and of the soil-mantling litter and duff, intensive drying of the soil, generation of wood ash, combustion of soil-binding organic matter, and the enhancement or formation of water-repellent soils can change the infiltration characteristics and erodibility of the soil. These changes can lead to decreased rainfall infiltration, subsequent significantly increased overland flow and runoff in channels, and movement of soil. Rainfall on burned watersheds can transport and deposit large volumes of sediment both within and down-channel from the burned area, both by flash flood and debris flow. Debris flows can be one of the most hazardous consequences of rainfall on burned hillslopes. They pose a hazard distinct from other sediment-laden flows because of their unique destructive power. Debris flows can occur with little warning, can exert great impulsive loads on objects in their paths, and even small debris flows can strip vegetation, block drainage ways, damage structures by impact and erosion, and endanger human life. Debris flows generated from recently burned basins differ from those produced from unburned hillslopes in that very little, to no, antecedent rainfall is required, they occur in response to short duration, high intensity (but short recurrence interval) rainstorms, and they are rarely mobilized from a discrete landslide source.

Warnings and Watches for post-fire flash flood and debris flow can be based on region-specific rainfall intensity-duration thresholds. Such thresholds have been developed for recently burned basins in southwestern Colorado and for regions within southern California by comparing conditions in storms known to have produced debris flows with those that produced flash flooding and those that showed no response. Thresholds are defined by identifying those combinations of rainfall intensity and duration that are unique to flash flood and debris-flow producing storms. Where available, information on known times of debris-flow occurrence is incorporated into the thresholds. Threshold lines delineate a range of rainfall combinations – from short duration, high intensity to longer duration, low-intensity – any of which can result in flash flood or debris-flow activity. Post-fire threshold conditions change with time as sediment supplies are depleted and vegetation recovers. Thresholds incorporated into the FFMP (Flash Flood Monitoring and Prediction) tool form the basis of a joint NOAA-USGS demonstration debris-flow warning system for recently burned basins in southern California. Possibilities to enhance warning systems to provide spatially and temporally explicit information on post-wildfire runoff and erosion hazards include the real-time generation of maps that show the probability and magnitude of debris flows from individual drainage basins, and of areas that can be inundated by these events.

Snow model evaluations for ensemble streamflow forecasting

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The National Weather Service River Forecast System snow accumulation and ablation model (SNOW17) is a conceptual, single-layer, temperature-index based model with a seasonally varying melt factor. This model is loosely coupled to the NWS rainfall-runoff model (SACSMA) and routing scheme, and is used to generate short-term to long-term streamflow predictions throughout the US. Numerous snow models with varying degrees of complexity have been created since the development of the SNOW17, with applications ranging from point to basin scale and from research to hydrologic operations. Intensive data requirements has been stated as the main reason for keeping more complex snow models out of operations for decades. However, the continual development of new data sets, primarily through remote sensing, may help eliminate these data limitations to some degree, currently and in the future. The question is then whether the efforts of incorporating a more advanced model into operational forecasting is worth the possible benefits (if any) in improved streamflow predictions. This study investigates the performance of a three-level snow energy balance model (the Snow Soil Atmosphere Scheme (SAST)) as compared to the SNOW17 model for a small experimental watershed in Idaho. Evaluations are based on point simulations of snow water equivalent, basin-scale streamflow simulations using the SACSMA, and hindcasts for a 13 year period.

Effects of applying average meteorological data to State Based Model

Jill Glenn, PE, Idaho Power Company and Dr. Fritz Fiedler, PhD, PE, University of Idaho

Long-term streamflow forecasting using the National Weather Service River Forecast System (NWSRFS) generally involves using the Extended Streamflow Prediction (ESP) model, which creates probabilistic forecasts by using historic temperature and precipitation time series to produce a number of equally likely streamflow traces. This technique works well in long-range planning when working with monthly or seasonal volume forecasts, but does not work well for mid-range planning when operations require more detailed daily information to manage reservoirs. In order to produce a reasonably accurate streamflow forecast, the hydrologist requires knowledge of the expected meteorology. Generalized weather forecasts provide the hydrologist with information about temperature and precipitation as it is related to the average (i.e. May: 1° above normal temperatures and 115% of normal precipitation). Mean Areal Precipitation (MAP) and Mean Areal Temperature (MAT) data can be analyzed to create monthly exceedence probabilities and average daily frequency analysis can produce 6-hour precipitation traces that agree with the expected monthly probabilities. Since the SNOW-17 and SAC-SMA models are state based, the application of an average precipitation trace may result in significantly different runoff volumes than applying an actual precipitation trace. Analysis will be performed to quantify the difference in the monthly volume simulated streamflow when applying the averaging technique verses the application of an historic precipitation trace.

Impact of Cloud Seeding Program

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The purpose of the present work is to evaluate the impact Idaho Power Company's cloud seeding operations have had on the Payette River Basin as a whole. In a river basin as complex as the Payette, additional water, in the form of snow, can alter reservoir operations, irrigation demands, and canal return flows, therefore, altering streamflow. An analysis was performed for water years 2003-2005 using the National Weather Service River Forecast System (NWSRFS), a suite of hydrologic models specifically designed to be used in an operational environment to provide streamflow forecasts for large and complex river basins. Four separate scenarios were run for comparison. In the first scenario, a control scenario, precipitation and temperature data were applied to the NWSRFS to generate a streamflow simulation from October 1, 2001 to October 1, 2005. In the second, third, and fourth scenarios, that same data was applied to the NWSRFS to simulate streamflow, but snow-water equivalent peaks for the established target areas were reduced by a factor, therefore reducing the simulated streamflow volumes in those target areas. The volumes from each of the reduced snow-water equivalent scenarios were compared independently with the simulated streamflow volume of the control scenario, thus assessing the impact that cloud seeding had in that scenario. In scenario two, a 9% reduction in snow-water equivalent peak was applied to water years 2003-2005, resulting in a 4% reduction in streamflow volume over the three year period. Scenario three involved a 10% reduction in snow-water equivalent over the same three water years, and resulted in a 5% reduction in flow volume. Scenario four reductions for each water year were based upon a snow-water equivalent target-control point analysis performed by the Idaho Power Company. The corresponding reductions were 16% for water year 2003, 5% for water year 2004, and 23% for water year 2005, resulting in a 6% reduction in streamflow over the three year period.

Improving the understanding and prediction of post-fire hydrology

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Rapid development in metropolitan regions has led to increased population growth and urban pressure at the urban-wildland interface. These interfaces, however populated, are now vulnerable to the natural processes that occur in wildland areas. This vulnerability was made evident in the outbreak of fires that occurred in Southern California in October of 2003. These fires were the worst outbreak in more than a decade, resulting in the deaths of 20 people, destroying 3500 homes, and consuming more than 750,000 acres (1,170 square miles). A multi-faceted investigation is being undertaken in the San Bernardino Mountains in eastern L.A. County to analyze the effects of these fires on hydrologic and biogeochemical flow processes. Field investigations indicate decreased permeability of soils due to an extensive hydrophobic layer and an extremely rapid response of the burned watersheds to precipitation inputs. Hydrograph separation from isotope studies support this finding with an increase in overland flow and a decrease in subsurface response. Post-fire calibrations of a hydrologic model (SAC-SMA) were also undertaken and show significant changes in parameter values relative to pre-fire conditions.

An Overview of NWS Burn Hydrology Efforts
Bill Reed and Dave Brandon

A diverse complement of burn hydrology efforts has been realized nationwide throughout the NWS in response to the unique hydrological forecasting concerns presented by these impacted areas. In general these techniques have been developed ad hoc and in isolation from each other. A survey of offices has been conducted by the authors; and an overview of known current and planned techniques utilized by the NWS is provided.

The Joint National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) and the United States Geological Survey (USGS) Debris Flow Warning Systems

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Landslides and debris flow cause loss of life and millions of dollars in property damage annually in the United States. In an effort to reduce loss of life by debris flows, in 2005 the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) and the United States Geological Survey (USGS) formed a task force to assess the feasibility of establishing a demonstration debris flow early warning system for recently burned areas in southern California, and to identify the necessary scientific advancements and costs associated with the expansion of such a system to unburned areas and, eventually, to a national scope.

That task force found that it is feasible for a demonstration debris flow warning system to be instituted for recently burned areas in southern California. Debris flows are common following wildfires in this setting, and representative rainfall intensity-duration thresholds for debris flow occurrence have been developed for parts of the region. The demonstration project covers an eight-county area, and is based on the existing NWS operational Flash Flood Monitoring and Prediction (FFMP) system. FFMP was modified to identify when both flash floods and debris flows are likely to occur based on comparisons between radar precipitation estimates and established rainfall intensity-duration threshold values. FFMP provides the most cost-effective and expedient approach to implement a warning system on a 24 hour, 7 day a week basis. Advisory outlooks, watches, and warnings will be disseminated to emergency management personnel through the Advanced Weather Information Processing System (AWIPS). The task force also recommended that a smaller area within the larger demonstration area be dedicated to intense instrumentation and research to enhance and develop new geologic, hydrologic, and hydrometeorologic methods for precipitation and debris flow forecasting precipitation measurement techniques. Although considerable potential exists for enhancing and expanding the warning system to provide spatially and temporally explicit information specific to debris-flow processes in unburned settings, significant resources and scientific advancements are necessary to realize this potential.